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USACE CONTRACT NO. DACW33-94-D-0002
TASK ORDER NO. 017
TOTAL ENVIRONMENTAL RESTORATION CONTRACT

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FINAL TECHNICAL MEMORANDUM
Revision 2

FEASIBILITY INVESTIGATION OF SEDIMENT DEWATERING ALTERNATIVES NEW BEDFORD HARBOR SUPERFUND SITE

New Bedford, Massachusetts

May 2001

Prepared for

U.S. Army Corps of Engineers
New England District
Concord, Massachusetts

2001-017-0133
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

Under Task Order No. 17 of the U.S. Army Corps of Engineers (USACE) Total Environmental Restoration Contract (TERC) No. DACW33-94-D-002 Foster Wheeler Environmental Corporation (Foster Wheeler) conducted a feasibility investigation of sand separation and mechanical dewatering technologies, and disposal options for the sediment to be removed from the New Bedford Harbor Superfund Site – Operable Unit No. 1. This Feasibility Investigation Report was based on a combination of literature searches, bench scale dewatering tests with representative sediment from the New Bedford Harbor Superfund Site, and conversations with mechanical dewatering vendors.

1.1 Feasibility Study Objectives

The objectives of this Feasibility Investigation of Desanding and Mechanical Dewatering Alternatives Report are:

a) Identify and evaluate sand separation and mechanical dewatering technologies which may be applicable to the New Bedford Harbor Superfund Site;

b) Determine what the volume reduction, weight reduction, and geotechnical properties may be achievable by desanding/mechanical dewatering;

c) Estimate the cost and scheduling for a desanding and dewatering system including the cost for only conducting sand separation;

d) Identify all material streams (sand, desanded sediment, filtrate from mechanical dewatering, filter cake) generated from a desanding/mechanical dewatering system including the chemical and physical characteristics;

e) Identify the range of off-site disposal options available for the solid waste streams and prepare an accurate estimate for the most cost effective option; and

f) Develop a conceptual site layout for a desanding and mechanical dewatering system.

1.2 Organization of the Report

The document is organized such that this section, Section 1.0, summarizes the feasibility investigation objectives and report organization. Sections 2.0 and 3.0 present and compare the physical separation and mechanical dewatering technologies evaluated, respectively. Section 4.0 summarizes the bench scale dewatering tests conducted on representative sediment from the New Bedford Harbor Superfund site; Section 5.0 provides a conceptual layout of a desanding/mechanical dewatering system; Section 6.0 provides a discussion of the reuse and disposal options available for the separated materials and filter cake; and Section 7.0 presents the conclusions and recommendations of the feasibility Investigation. The appendices contain descriptions of several sediment dewatering case studies, copies of each vendors bench scale dewatering report, dredging/desanding/dewatering mass balances, a summary of the regulatory programs applicable to the separated sand component and analytical data.

2.0 PHYSICAL SEPARATION TECHNOLOGIES

There are several reasons for the utilization of physical size separation technologies:

1) To prevent damage to the dredge and dewatering equipment by removing large debris (i.e. rocks, shells, wood, etc) from the dredged sediments;
2) To separate inorganic material such as sand from the fine-grained organic material that tends to contain the higher concentration of contaminants; and
3) Reduce the volume of (TSCA, RCRA) material and allow the oversized, less contaminated material to be potentially handled as a non-hazardous material.

Physical size separation is typically performed in two steps, oversized pre-screening and primary size separation (sands separated from the fines). Oversize pre-screening is usually performed with grizzlies and trommels, and primary size separation is typically conducted with vibrating screens, mechanical classifiers, hydrocyclones or settling basins. Descriptions of each of these physical size separation technologies are summarized in the following sections.

2.1 Oversized Pre-Screening

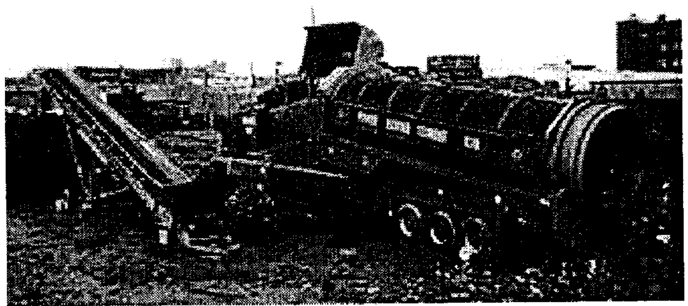
2.1.1 Grizzlies

Grizzlies are utilized for very coarse separation and are generally the first pre-screening step. A grizzly is a simple device consisting of parallel steel or iron bars with a 4-6 inch spacing between the bars. The bars are usually slightly inclined to facilitate the movement of material. Advantages and disadvantages for the grizzly are provided in Table 2-1.

2.1.2 Trommels

Trommels are revolving sieves generally used for sizing or screening in the crushed rock or ore industry. A trommel (Figure 2-1) consists of a slightly inclined, revolving cylinder constructed of wire mesh with openings from 6 mm to 10 cm depending on materials separation goals (i.e. designed for oversized debris removal or for primary size separation). The material to be screened is delivered inside the trommel at the higher end. The fine material drops through the screen openings and the oversized material will be delivered at the lower end by gravity. Due to its cylindrical shape, the trommel has poor capacity because only part of the screen is utilized. The main disadvantage of trommels is that clay balls may form in the trommel cylinder preventing the undersized material from passing through the screen. This can be minimized by application of a water spray. Advantages and disadvantages for the trommel are provided in Table 2-1. Case studies of projects that have utilized trommels are provided in Appendix A.

Figure 2-1
Trommel



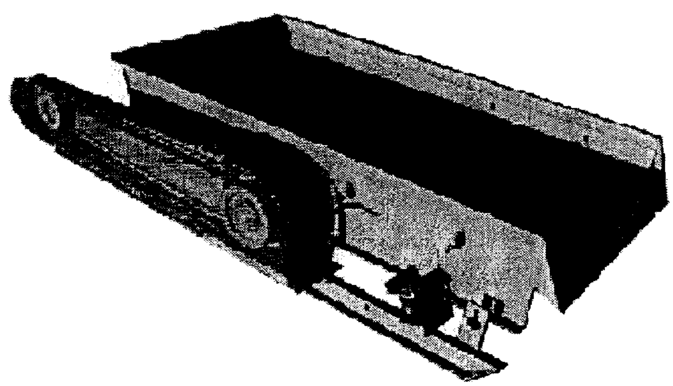
Powerscreen, http://www.powerscreen.co.uk/trommel.html

2.2 Primary Size Separation

2.2.1 Vibrating Screens

A vibrating screen (Figure 2-2) is a patterned, slotted flat surface, made of deck material and agitated to separate and move pieces resting on it. The vibrating screen consists of one or more slightly inclined screening surfaces mounted on a robust frame. The vibration is used to increase capacity and to prevent binding of the screen. The screen size can vary from 200 mesh to 1/2 inch. Advantages and disadvantages for the screen are provided in Table 2-2.

Figure 2-2
Vibrating Screen



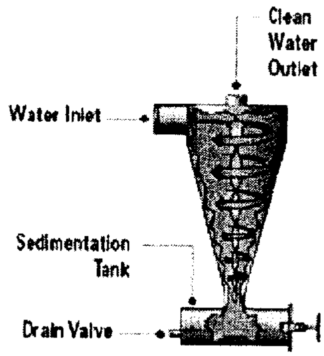
Greystone, http://www.greystoneinc.com/vibrate.html

2.2.2 Hydrocyclones

Hydrocyclones (Figure 2-3) are widely used in the sand, gravel, and mineral processing industries. The hydrocyclone separates particles within a slurry with different density or weight. The operation is based on the centrifugal force principal. There are no moving parts in the hydrocyclone and it requires relatively low energy to operate.

As shown in Figure 2-3, sediment enters the hydrocyclone at high velocity through the inlet opening and flows into the swirl chamber. As the liquid swirls downward in the conical separation chamber, its velocity increases. The larger sand particles are thrown against the walls, forced to the bottom, and discharged through the apex nozzle as cyclone underflow. Due to the cyclonic flow, a low-pressure vortex is created in the center of the hydrocyclone and the lighter, finer grained sediments and water flows upward and exits at the top of the hydrocyclone.

Figure 2-3
Hydrocyclone



http://www.netafim-usa.com/ag/products/filtration_hydrocyclone.asp

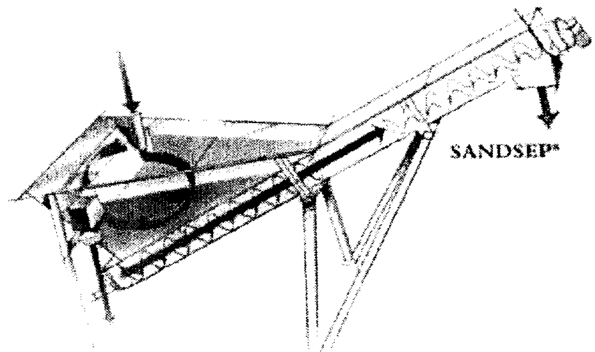
Sizing of the hydrocyclone is important to achieve desired separation. The fines typically carry most of the contamination and it is important to separate the sand underflow from the fines. Some fines will exit the hydrocyclone with the underflow water and therefore it is critical to keep the underflow water to a minimum. This can be achieved by the sizing of the apex nozzle. Additional methods of reducing the underflow fines include running the underflow through a second hydrocyclone in series with the first or discharging the underflow on to a tight mesh vibrating screen (100-200 sieve size) to retain the sand and allow fine grained sediments to pass. Advantages and disadvantages for the hydrocyclone are provided in Table 2-2.

2.2.3 Mechanical Classifiers

Mechanical classifiers may be used for size separation of materials in the 1-300 micron range, similar to the range for hydrocyclones and vibrating screens. There are two kinds of mechanical classifiers, screw (or spiral) (Figure 2-4) and rake classifiers.

A screw classifier consists of a sloped tank equipped with one or two screws mounted inside the tank. The screws rotate, creating agitation and separation of the material. The coarser fraction (sand) is conveyed and drained by the spiral and discharged. The disadvantages of mechanical classifiers are that they are very sensitive to deviations in the feed rate and solids content of the material. Advantages and disadvantages for the classifier are provided in Table 2-2.

Figure 2-4
Screw Classifier



http://www.spirac.com.au/products/sediment_separator.html

2.2.4 Settling Basins

Settling basins are based on the principle that different particles settle at different rates. Fine sand with a diameter of 0.1 mm needs approximately 38 seconds to settle one foot while it takes silt with a 0.01 mm diameter 33 minutes to settle the same distance. Therefore the materials to be separated are normally discharged to a large settling basin where the sand fraction settles out and the fines flow through the basin for further separation/dewatering. Once the basin is filled the sand fraction is removed. Advantages and disadvantages for the settling basin are provided in Table 2-2.

2.3 Summary

A grizzly is the oversized pre-screening technology of choice due to its simple design and function. This technology will likely be utilized as part of the dredging operations to remove + 4 inch material prior to the sediment being pumped to the dewatering system.

For the primary size separation, technologies that are considered to be effective for the New Bedford Harbor project are screens, hydrocyclones and the screw classifiers. Each of these separation technologies has been effectively utilized alone or in combination to separate sand fractions from dredged sediments. Settling basins are generally utilized for efficiently separating material consisting of a sand fraction greater than the silt fraction. New Bedford Harbor Superfund sediments contain approximately 10% sand by volume and would not be a good candidate for settling basins. In addition, there is limited space available for settling basins.

Table 2-1
Summary of Physical Separation Technologies, Oversized Pre-Screening

Oversized Pre Screening	Size of Material Passing (C)	Capacity (A)	Advantages	Disadvantages
Grizzlies	4 inch	Limited by loading equipment	– Low maintenance – Effective on wet and dry material – Can be combined with a feed hopper	– Typically separates large particles only – Not satisfactory for most "sticky" material (e.g. clay)
Trommels	25-100 mm	40-720cy/hr (fixed) 25-500 cy/hr (mobile)	– Can be arranged in series to achieve greater separation – Ideal for preparing feed soils for additional treatment	– Poor capacity/Relatively inefficient – Slots are prone to clogging – Requires power – Could require spray water to prevent formation of clay balls **(D)**

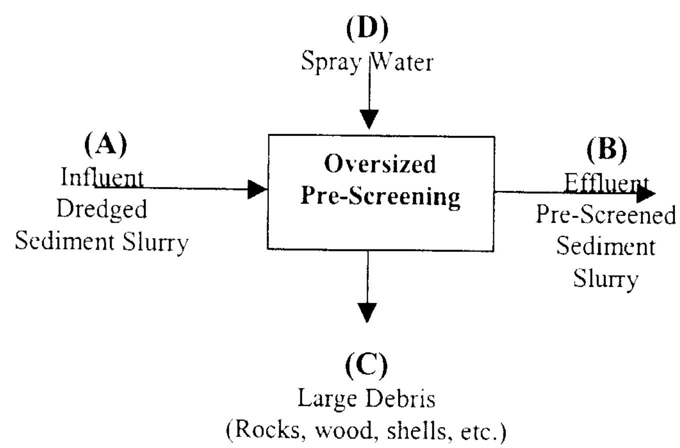
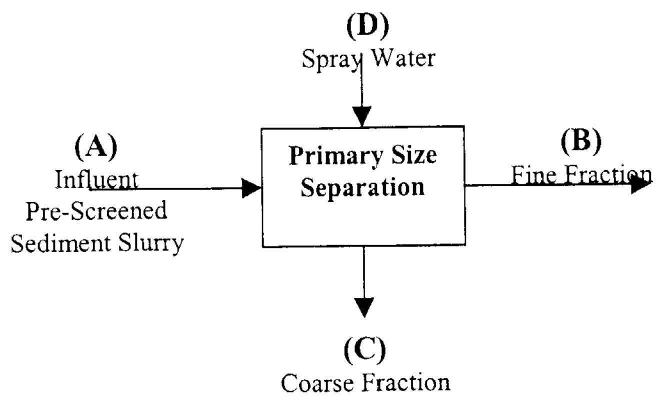


Table 2-2
Summary of Physical Size Separation Technologies, Primary Size Separation

Primary Size Separation	Size of Material Passing (B)	Capacity (A)	Advantages	Disadvantages
Mechanical Classifiers	1-1500 µm	Up to 500 gpm	– Oversize material discharged with a high solids content **(C)**	– Sensitive to deviations in feed rate and solids content **(A)**
Vibrating Screens	75 µm – 13 mm	Up to 1500 gpm	– Oversize material discharged with a high solids content **(C)** – Durable, low maintenance – Can be designed to separate down to small particle sizes	– Screen blinding can occur, typically requires spraying with water **(D)**
Hydrocyclones	5-400 µm	Up to 1500 gpm	– Requires little energy – No moving parts inside the hydrocyclone – Can be manifolded in parallel to increase throughput	– Low capacity – Requires constant feed rate for high efficiency
Settling Basins	-	-	– Requires little energy – Low maintenance	– Space requirement – Typically used for material with a greater percent sandy than silty material – Sand removal requires relatively large construction effort



3.0 MECHANICAL DEWATERING TECHNOLOGIES

There are three primary methods of mechanically dewatering solid/liquid mixtures such as sediments. These methods are the belt filter press, plate and frame filter press and centrifuges. A description of each as well as their advantages and disadvantages are provided in the following sections.

3.1 Plate and Frame Filter Presses

The plate and frame filter press is an assembly of alternate solid plates, the faces of which are studded, grooved, or perforated to permit drainage, and hollow frames, in which the cake collects during filtration. A replaceable filter medium, usually a fabric, covers both faces of each plate. The plates are usually rectangular and are hung in a vertical position on a pair of parallel support bars.

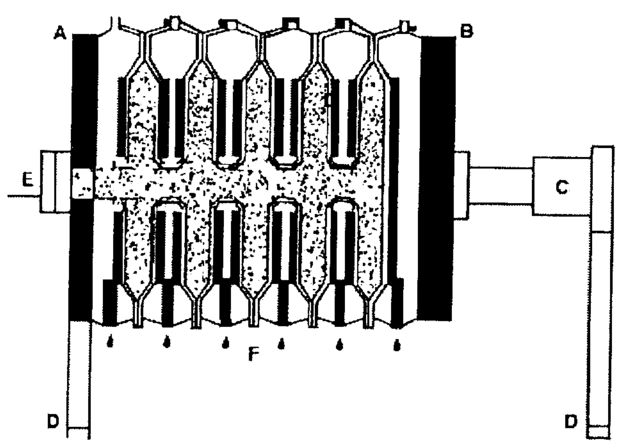
There are two basic modern designs: the recessed plate press and the diaphragm plate press. A brief description of each is provided in the following sections.

3.1.1 Recessed Plate Filter Press

The fixed volume, recessed plate filter press (Figure 3-1) consists of a series of rectangular plates, recessed on both sides, that are supported face to face in a vertical position on a frame with a fixed and movable head. A filter cloth is hung or fitted over each plate. The plates are held together with sufficient force to seal them so as to withstand the pressure applied during the filtration process. Hydraulic rams or power screws are used to hold the plates together.

In operation, chemically conditioned sludge (10 – 15% solids by weight) is pumped into the space between the plates. A cycle can run 1-3 hours to a filtration pressure of 100-225 psig, forcing the liquid through the filter cloth and plate outlet ports while the solids form a cake on the filter's surface. When dewatering ceases, the filter press is opened by retraction of the moveable head and individual vertical plates are moved sequentially over a gap allowing the caked solids to fall off. After the cake is removed, the plates are pushed back into place by the moveable head and the press is closed for the next dewatering cycle.

Figure 3-1
Recessed Plate Filter Press



A – Fixed Head
B – Movable Head
C – Hydraulic Cylinder
D – Supporting Legs
E – Feed Pipe
F – Discharge

Netzsch http://www.netzschusa.com/FilterPress/FilterPressmain.htmfrontiertech.simplenet.com/FTIproducts.htm

The filter cake thickness varies from 1 to 1.5 inches, and the solids by weight vary from 30-60% depending on the material being dewatered. The filtration cycle time includes the time required to 1) feed the press from 0 to a terminal pressure of 100-225 psig, 2) terminate feed and allow pressure to drop to 0 psig, 3) open the press, 4) discharge the cake, and 5) close the press. Depending on the degree of automation incorporated into the machine, operator attention must be devoted to the press during feed, discharge and open-close intervals..

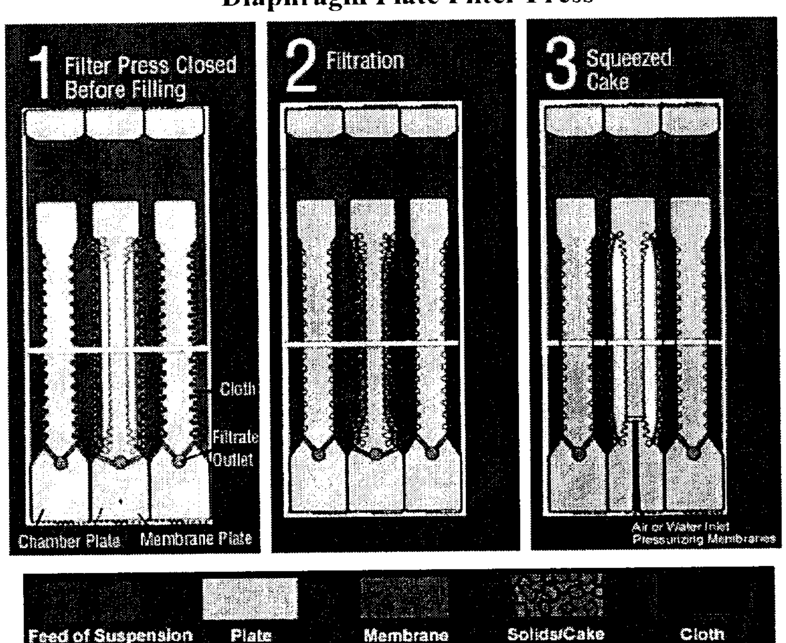
Important operational variables for the recessed filter press include: the feed pressure, filtration time, conditioner type and dosage, and type of filter cloth. The advantages and disadvantages for the plate and frame filter press are provided in Table 3-1. Case studies of projects that have utilized plate and frame filter presses are presented in Appendix A.

3.1.2 Diaphragm Plate Filter Press

The diaphragm plate filter press (Figure 3-2) is similar to the recessed plate press except that a flexible, inflatable diaphragm is placed behind the filter media. The diaphragm expands via air or water to achieve the final squeeze pressure after the feed cycle, thus reducing the cake volume during the compression step. Generally about 10 to 20 minutes are required to fill the press and 15 to 30 minutes of squeeze pressure are required to dewater the cake to the desired solids content. Diaphragm presses are generally designed for 80-100 psi for the fill/feed stage of dewatering, followed by 100-225 psi for final compression. Diaphragm presses can handle a wide variety of sludges with good performance results.

Important operational variables for the diaphragm plate filter include: sediment fill/feed and diaphragm pressures, conditioner type and dosage, fill/feed and diaphragm squeeze times, and type of filter cloth. The advantages and disadvantages for the diaphragm plate filter press are provided in Table 3-1. Case studies of projects that have utilized diaphragm plate filter presses are presented in Appendix A.

Figure 3-2
Diaphragm Plate Filter Press

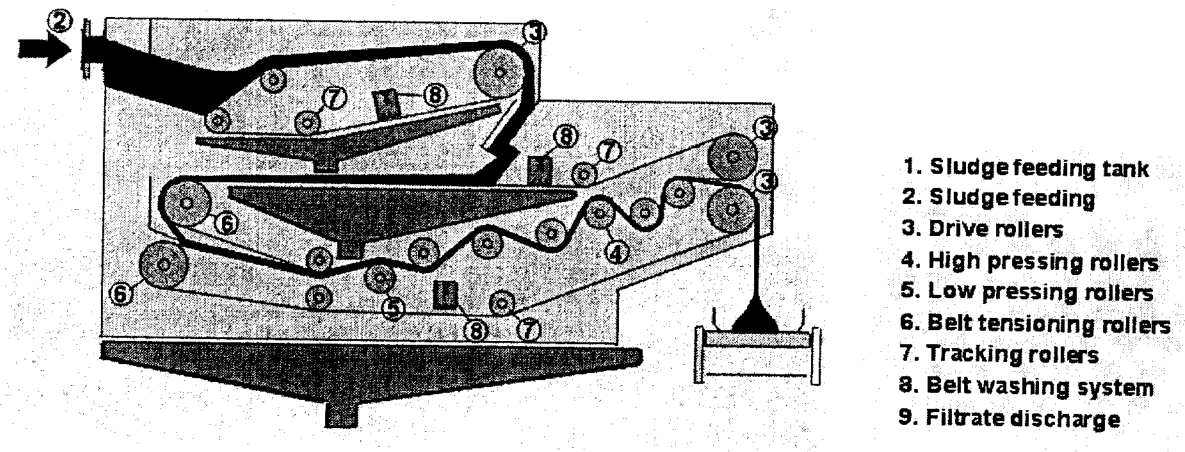


Klinkau America http://www.klinkauamerica.com/prod_membrane.htm

3.2 Belt Filter Press

Belt filter presses (Figure 3-3) are continuous-feed sludge-dewatering devices that involve the application of chemical conditioning, gravity drainage, and mechanically applied pressure to dewater sludge. The belt filter press was introduced in the US in the early 1970s and has become one of the predominant sludge-dewatering devices in municipal wastewater treatment plants.

Figure 3-3
Belt Filter Press



OY Ekotuotanto AB. http://www.ekotuotanto.fi

A belt filter press is a continuous sludge-dewatering device that combines cake formation with chemical conditioning under gravity drainage with cake dewatering by mechanical compression between two moving belts of cloth. Belt filters have been used mostly for dewatering of sludge from biological treatment of municipal sludges. Most belt filters include a flocculation chamber where a polymer is added to the feed sludge to agglomerate the particles. Proper flocculation of the sludge is important to create solids that will dewater readily under gravity and form a cake with sufficient mechanical strength to be squeezed without being extruded from the belts. The sludge is fed onto the top of the first moving belt, where it is gravity thickened as liquid filters through the belt. The belt then makes a sharp turn over a roller, and the sludge is discharged onto the second moving belt. The two belts then advance together and slowly converge to apply pressure to form a cake and begin the dewatering portion of the process. Sufficient water must be removed in this low-pressure dewatering step to create a sludge cake that is firm enough that it does not squeeze out from between or the edges the belts. The sludge cake is subjected to progressively higher mechanical compression by running the two belts together over smaller rollers. The repeated changes in belt curvature shear the cake and promote dewatering. A final compression step using a hydraulically applied set of rollers may be used before the belts diverge and the cake is discharged. The belts are then washed and realigned before returning to the initial step.

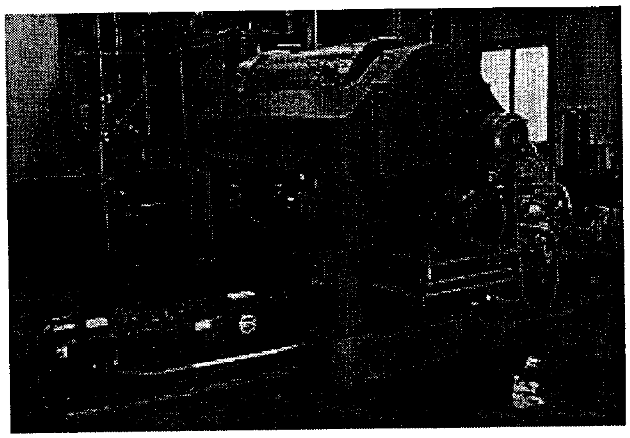
Variables that affect the performance of the belt filter press include: sludge characteristics, the method and type of chemical conditioning, the pressure developed, machine configuration, belt porosity, belt speed, and belt width. The belt filter press is sensitive to wide variations in sludge resulting in improper conditioning and reduced dewatering efficiency. Based on actual operating experience, it has been found that the solids throughput is greater and the cake dryness is improved with higher solids concentrations in the feed sludge.

The advantages and disadvantages for the belt filter press are provided in Table 3-1. Case studies that have utilized belt filter presses are presented in Appendix A.

3.3 Centrifuge

The centrifuge (Figure 3-4) is widely used in industry for separating liquids of different density, thickening slurries, and removing solids. The process is applicable to the dewatering of wastewater sludge and has been used with varying degrees of success in both the U.S. and Europe. Centrifuges are generally used in conjunction with flocculants and can be used to dewater or concentrate soils and sediment ranging in decreasing size from fine gravel to silt. Two types of centrifugal devices are typically used for thickening sludge: solid bowl and imperforate basket. A brief description of each is provided in the following sections and summarized in Table 3-1.

Figure 3-4
Centrifuge



http://www.westfaliaseparatorus.com/article.html#article

3.3.1 Solid Bowl Centrifuge

The solid bowl centrifuge is the most commonly used centrifuge for dewatering. In the solid bowl machine, polymer conditioned sludge is fed at a constant rate into a rotating bowl, where centrifugal force separates the sediment into a cake and a filtrate stream called "centrate". The centrate will contain fine, low density solids and is typically returned to a filtrate treatment system. The sludge cake is discharged from the bowl by a screw feeder into a hopper or onto a conveyor belt. Depending on the type of sludge, solids concentrations in the cake generally vary from 10% to 35% although newer designs can achieve solids concentrations in the 30% to 35% range.

Solid bowl centrifuges are suitable for a variety of sludge dewatering applications. The units can be used to dewater sludges of high specific gravity particles with no prior chemical conditioning, but solids capture and centrate quality are poor unless solids are conditioned with polymers. Chemicals are added to the sludge-feed line or to the sludge within the bowl of the centrifuge. Dosage rates for conditioning with polymer vary from 2 to 15 lbs/ton of sediments (dry solids).

3.3.2 Imperforate Basket Centrifuge

Imperforate basket centrifuges (IBC) are particularly suitable for small plants and therefore not suitable for the New Bedford Harbor Project. The IBC is similar to the plate and frame filter press in that it operates on a batch basis. The liquid sludge is introduced into a vertically mounted spinning bowl. The solids accumulate against the wall of the bowl and the centrate is decanted. When the solids holding capacity of the unit has been achieved, the bowl decelerates and a scraper is positioned in the bowl to help remove the accumulated solids. The IBC is particularly well suited for soft or fine solids that are difficult to filter or where the nature of the solids varies widely.

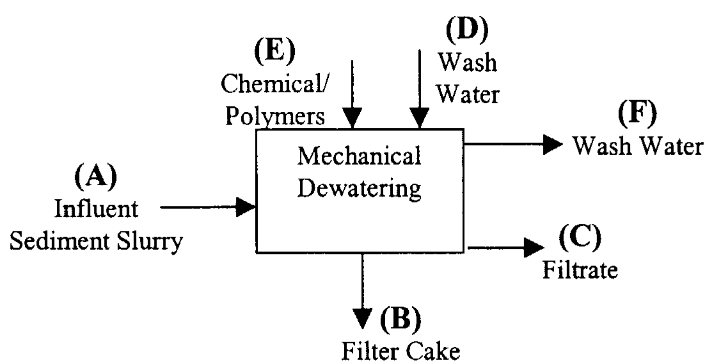
3.4 Mechanical Dewatering Summary

Based on the evaluation conducted for this feasibility investigation, the mechanical dewatering technologies considered applicable for the New Bedford Harbor sediments and requiring further evaluation include the belt filter press and plate and frame filter press utilizing diaphragm plates. Both technologies have been successfully applied to river/ocean sediments and are capable of generating a filter cake containing 30 to 70 % solids (by weight). The centrifuge technology, however, was not considered feasible for the New Bedford harbor sediments. The centrifuge does not generate as a high solids content filter cake (10 – 35%) as the other two dewatering technologies and is more susceptible to abrasive material. Centrifuges were used by Cognis-Bescorp for a soil remediation project at Twin Cities Army Ammunition plant. Quanlitatively, they appeared to work well, but in general centrifuges are considered to be an expensive dewatering alternative.

Table 3-1
Summary of Mechanical Dewatering Technologies

Mechanical Dewatering Technology	Continuous Feed or Batch Process	% Dry Solids of Filter Cake (B)	% Solids Captured	Cycle Time	Polymer Required (E)	Advantages	Disadvantages
Recessed Plate Filter Press	Batch	30-60%	+98%	1-3 hrs.	Yes	– Produces filter cake with high solids content **(B)** – High solids capture – Low TSS in filtrate **(C)** – Volume reduction of ~50% for sediment with 45% in-situ solids content **(B)** – No wash water	– Batch Operation – Operator monitoring needed at cake discharge sequence – Clogging with fines can occur if improper conditioning
Diaphragm Plate Filter Press	Batch	48-70%	+98%	1-1.5 hrs	Yes	– Produces filter cake with highest solids content **(B)** – High solids capture – Low TSS in filtrate**(C)** – Volume reduction of ~50% for sediment with 45% in-situ solids content – Can produce a filter cake even if improperly polymer conditioned (i.e., under/over dosing) – Consistent percent solids (by weight), cycle to cycle – No wash water	– Batch Operation – Operator monitoring needed at cake discharge sequence – Clogging with fines can occur if improper conditioning

Mechanical Dewatering Technology	Continuous Feed or Batch Process	% Dry Solids of Filter Cake (B)	% Solids Captured	Cycle Time	Polymer Required (E)	Advantages	Disadvantages
Belt Filter Press	Continuous	25-45%	+90%	N/A	Yes	– Continuous Operation – Relatively low labor and power requirements	– Lower % solids filter cake generated than with plate and frame – Volume reduction negligible (~10%) for 45% in-situ solids sediment – Lower solids capture, poor filtrate quality (+200 ppm TSS) will stress water treatment – High use of polymer – Wash water requiring treatment 70-100% of influent flowrate. – Performance sensitive to feed characteristics and chemical conditions – Clogging with fines can occur – Belts can deteriorate quickly in the presence of abrasive material
Solid Bowl Centrifuge	Continuous	10-35%	+90%	N/A	Yes	– Continuous Operation – Adaptable to either thickening or dewatering slurries	– Lower % solids filter cake generated than with plate and frame – Less capture of TSS will stress water treatment – Backwash water stream required – Sensitive to oversized/abrasive material – High energy and maintenance
Imperforate Basket Centrifuge	Batch	25-30%	+90%	N/A	Yes	– Continuous Operation – Adaptable to either thickening or dewatering slurries	– Low capacity – Lower % solids filter cake generated than with plate and frame – Less capture of TSS will stress water treatment – Backwash water stream required – High energy and maintenance – Not practical in large volume applications



4.0 BENCH SCALE DEWATERING TESTS

In order to further evaluate the feasibility of sand separation and mechanical dewatering, three different (3) bench scale dewatering tests were conducted at the New Bedford Harbor Superfund Site. The vendors selected were Koester Environmental Services, Inc. (Koester), Mineral Processing Services (MPS), and JCI/UPCYCLE. Each vendor represented a different mechanical dewatering technology (belt filter press, plate and frame filter press utilizing diaphragm plates, and bladder press) and a different industrial application (environmental and commercial). A summary of each vendor's desanding/mechanical dewatering process, bench scale test results, and conclusions are provided in the following sections.

The objectives of the bench scale tests were:

1) Evaluate if the New Bedford Harbor sediments can be effectively and economically dewatered by mechanical means and achieve significant weight and volume reduction;

2) Evaluate how much and what size fraction of sand can be practically separated from the sediment;

3) Determine the PCB concentrations of each separated fraction (filter cake, debris and sand reject, and filtrate);

4) Evaluate the geotechnical properties of the filter cake generated;

5) Estimate the quantity and quality of the dewatered water generated; and

6) Estimate the costs for a full scale desanding/mechanical dewatering system.

In order to achieve these objectives, each vendor was provided with a representative sample of sediment from the New Bedford harbor Superfund Site. The sediment was collected from the upper harbor in the vicinity of proposed CDFs C and B. The PCB concentration ranged from 940 mg/kg to 3,300 mg/kg (ppm), the solids content averaged approximately 45% (by weight), the wet density averaged 83 lbs/ft^3, and the dry solids sand content averaged approximately 40% (by weight). These values are considered average for the top two feet of sediment from the Upper Estuary of New Bedford Harbor.

The filter cakes generated were tested for moisture content, specific gravity, % solids (by weight), compressive strength, grain size analyses, moisture content/dry density, proctor tests, Atterberg Limits, consolidation tests, triaxial shear tests, and PCB concentration. Filtrate from the dewatering tests was analyzed for PCBs, metals, and total suspended solids (TSS).

4.1 Koester Environmental Services, Inc.

Koester Environmental Services, Inc. is an environmental contractor that specializes in dredging and dewatering sediments. Their proposed dewatering system would consist of vibrating screens, hydroclones and a plate and frame filter press utilizing diaphragm plates. In order to determine the feasibility of utilizing this desanding/dewatering system on the New Bedford Harbor sediments the following three-step bench scale testing process was conducted:

1) Sand Separation

   Sand was separated by addition of harbor water on a volumetric basis of two parts water to one part sample to produce a dredged slurry. The sediments were screened through 3/8" mesh to replicate vibrating screens. The coarse screened sediments were then screened through a 200 sieve to replicate a recirculating hydrocyclone process with 200 sieve vibrating screening of the underflow fines. The rejected material was washed twice with 1 ½ gallons of harbor water to replicate a 200 mesh linear motion vibrating screen. The desanded sediments had a percent solids by weight of approximately 15%.

2) Polymer addition

Desanded sediments were put through a phase of jar tests to determine which polymers would produce the desired consistency of flocculation for water release and filtration. Out of nine polymers tested, two produced desirable results.

3) Dewatering

Utilizing a diaphragm plate and frame filter press with two (2) 470mm x 470 mm (18" x 18") plates, Koester Environmental Services, Inc. (Koester) conducted bench scale testing with desanded sediment. The desanded sediments, a 15% solids slurry, were pumped into the filter press, and upon exit from the press a 62.5% to 66.7% solids by weight filter cake was produced. The moisture content of the filter cake ranged from 49.9% to 60%, and the wet density ranged from 104.2 lbs/ft^3 to 111.69 lbs/ft^3 . Filtrate from Koester's bench scale test was analyzed for PCBs, metals, and TSS. The +3/8 inch, + 200 mesh and filter cake were analyzed for PCBs only. A summary of the PCB results are provided below and the complete analytical data is presented in Appendix E.

Material	PCB Concentration
Feed Material	941 ppm
+3/8 Inch Material	698 ppm
+ 200 Mesh Material	49 ppm
Filter Cake	1630 ppm
Filtrate	12 ppb

The filter cake samples were also collected for geotechnical testing. These tests included grain size, proctor tests, atterberg limits, consolidation tests and triaxial shear tests. To data the geotechnical data is incomplete and will be provided in a separate technical memorandum along with the MPS geotechnical data. A complete description of the bench scale test and results are provided in Koester's bench scale report, which is presented in Appendix B.

Using the data obtained from bench scale testing, Koester generated a forecast budget for a complete desanding and diaphragm plate filter press dewatering system for treatment of the estimated 750,000 yd^3 of PCB contaminated sediment from New Bedford Harbor over a three year period.

The full-scale project was estimated at a production rate of 250,000 yd^3 of in-situ material per year based on two 10-hour shifts per day, 6 days per week. Each shift would consist of a 14-person crew. The dewatering process would include an onshore dredge slurry tank, all desanding and dewatering processes, and transport of the filter cake to a stockpile at the dewatering site. A mass balance for the proposed desanding/dewatering operation is provided in Appendix C and a summary of the projected output from a full scale plate and frame dewatering system are provided below.

Dewatered Solids:	62.5-66.7% dry solids
System Capacity filtercake production:	22 yd^3/ hr
Press cycle time:	1 ½ hrs
Penetrometer Unconfined Strength:	>2 tons/ft2

Based on bench scale results the desanding/dewatering portion of the project is estimated to cost an average of $68.50 per in-situ cubic yard not including mobilization cost. The total cost for mobilization, demobilization and fixed costs (setup, decontamination, dismantling) would result in a budget figure of $52.975 million for three years ($1.6 million for mobilization/de-mobilization and fixed costs). Further conversations with Koester representatives have indicated that this price estimate is conservative due to uncertainties associated with the bench scale testing and that the price would likely be in the $50.00 per in-situ cubic yard. This number has been verified in conversation ($50 ± 10%) with Mobile Dredging & Pumping Co., plate and frame filter press vendor, during a site visit. Koester has also indicated that desanding operation account for approximately 20% of total cost (i.e. $10-14/yd^3).

4.2 Mineral Processing Services, LLC (MPS)

Mineral Processing Services, LLP (MPS) provides services and equipment to primarily the mining industry. They have extensive experience in material separation and dewatering as it relates to this industry. In order to determine the feasibility of MPS's proposed desanding/dewatering system the following bench scale test procedure was conducted:

1) Sand Separation

   Sand separation was achieved by diluting and mixing the sediment with harbor water to create a slurry. The slurry was then mixed and processed through a sand screw classifier to remove particles greater than 100 mesh. Next, the sand was washed to remove visible silt and clay contaminants. The sand separation process removes 23% of the total solids by weight and generates a slurry that is 12% dry solids by weight.

2) Sedimentation and Thickening

   In the sedimentation and thickening step, a polymer is added to the 12% dry solids slurry and is allowed to sit to further separate the solids. The result of this process is thickener solids discharge that is 34% dry solids.

3) Dewatering

   The final step of MPS's bench scale dewatering process is performed using a modified diaphragm plate and frame filter press (three chambers). MPS applied the anticipated terminal pressure (100 psi) for increasing periods of time in order to simulate the sediment passing through a high intensity press (HIP) or "bladder press". The HIP combines both the advantages of a continuous belt filter press and the lower terminal pressures achieved in a plate and frame filter press (100 psi). The sediment slurry is conditioned with polymer and fed into a single pass belt filter press. A bladder cavity is inflated in increments with water to apply high pressure to the revolving belt and as a result dewaters the slurry contained between them. More detailed information on the bladder press can be found in the MPS Bench Scale report (Appendix B).

MPS's dewatering process produced a filter cake with a dry solids content that ranged from 47% to 54% by weight. The moisture content of the filter cake ranged from 85 % to 113 %. The filter cake and separated materials were not chemically characterized but samples of the filter cake were submitted for geotechnical testing (grain size, proctor tests, Atterberg Limits, consolidation tests and triaxial shear tests). As with Koester, the geotechnical data is still incomplete and will be submitted under a separate technical memorandum.

MPS estimated the cost to desand and dewater the sediments at New Bedford Harbor at $15.39 per in-situ cubic yard. This gives an estimated project cost of $11.542 million. A mass balance for the proposed desanding/dewatering system is included in Appendix C and a summary of the projected output from a commercial Bladder Press Dewatering system is provided below:

Polymer Usage:	3lbs./wet ton
Thickened Solids:	37% dry solids
Dewatered Solids:	55% dry solids
System Capacity @ 12% d.s.:	650 gpm
System Wet Tons/Hour:	36 wet tons/hr
Water Discharge, suspended solids:	45mg/l
Penetrometer Unconfined Strength @ 62.3% solids:	1.5 tons/ft2
Penetrometer Unconfined Strength @ 58.0% solids:	1.0 tons/ft2
Penetrometer Unconfined Strength @ 52.4% solids:	0.5 tons/ft2

MPS recommends that:

- All equipment selected for project application be flexible in its design.
- A determination be made of what end product characteristic is best suited for each handling point.
- The coarse fraction that passes the 100 mesh, but is retained on the 200 mesh be allowed to enter the fines dewatering operation to achieve a filter cake with proper compaction and handling characteristics.

A complete description of the bench scale test, results, and full-scale process descriptions are provided in MPS's bench scale report (Appendix B). In the report, MPS is using a dredge influent of 500 gpm @ 30% dry solids. This assumption was made prior to starting the Pre-Design Field Test (PDFT).

4.3 JCI/Upcycle Associates, LLC

JCI/Upcycle Associates, LLC (JCI/Upcycle) is a joint venture between New Providence, New Jersey based Upcycle Aggregates and Jay Cashman, Inc of Boston, Massachusetts. JCI/Upcycle's innovative technology utilizes belt filter presses to dewater sediments and then converts the filter cake to an uncontaminated re-usable product with a high temperature processing unit. For the New Bedford Harbor Superfund project, JCI/Upcycle would not convert the dewatered sediment to light weight aggregate. In order to determine the feasibility of proposed dewatering system JCI/Upcycle conducted the following four step bench scale tests:

1) Sand Separation

   To remove coarse material and debris, the sediments were slurried by addition of harbor water on a volumetric basis of two parts water to one part sample. The sediments were screened through a 3/8" mesh screen. No full-scale primary size separation process was proposed by JCI/Upcycle because no significant sand fraction was present in the sediment samples tested.

2) Polymer addition

   Addition of a polymer to screened sediments to enhance flocculation.

3) Primary Dewatering

To remove fluidized water, a proprietary dewatering technique is utilized. The primary dewatering technique that separates flocculates from water by virtue of their size rather than by settling.

4) Secondary Dewatering

Secondary dewatering, removal of interstitial water trapped by the flocculated solids, is accomplished by a belt filter press. The primary dewatered solids delivered to the belt filter press are optimally dosed and ideally flocculated and contain minimal free water. Since the belt filter press does not need to accomplish primary dewatering (conventionally done by running the press slowly enough to permit water to gravity drain through the filter fabric), the proprietary technology allows the press to be run at a very high speed, up to double the top speed of conventional belt filter presses.

JCI/UPCYCLE bench scale data indicated that the New Bedford Harbor sediment is responsive to flocculation and therefore amenable to commercial scale-up. A mass balance for the proposed dewatering system is included in Appendix C and the following parameters are projected to provide reasonable expectations from a commercial operation.

Dredge Slurry Flow Rate	800 to 1,500 gpm
Slurry (% solids by weight)	8 – 12 %
Solids Mass Flow Rate	21 – 40 dry tons/hr
Flocculant (emulsion) Requirement	63 to 120 lbs/hr
Flocculant (@ 0.5%) Requirement	25 – 48 gpm
Solids Product (@ 45% solids, by weight)	43 – 98 yd^3/hr

Should higher throughputs be required, additional identical processing trains could be replicated and installed.

JCI/UPCYCLE estimated the cost to dewater the sediments at New Bedford Harbor to be between $40 and $45 per in-situ yard. This gives an estimated project cost of $30-$33.75 million. This cost does not include cost for primary size separation, which is estimated at 20% of the total dewatering cost. Primary size separation would increase the cost to $50-$56.25 per in-situ ton. A solids product of 45% solids by weight is the same as the in-situ solids content and therefore no volume reduction, except from oversized material removal, is achieved with the belt filter press. It should be noted that the JCI/UPCYCLE bench scale tests did not generate a representative sample of filter cake. Therefore, physical or geotechnical testing could not be conducted. A complete description of the bench scale testing, results, and full scale process descriptions is provided in JCI/Upcycle's bench scale report (Appendix B).

4.4 Summary of Bench Scale Testing

All three vendors indicated that the sediment samples tested dewatered very well. The bench scale dewatering tests resulted in a filter cake containing percent solids ranging from 45 to 60% (by weight). All three dewatering technologies are technically feasible and final selection will be dependent on the final disposition of the filter cake (i.e., on-site CDF or off-site landfill) and the geotechnical requirements. For on-site disposal, volume reduction and placement requirements are more critical where as for off-site disposal, weight reduction is the more important. A comparison of each technology is provided in the following sections and Table 4-1 through 4-3.

4.4.1 Mass Balances

Mass balances were developed based on bench scale estimates and in-situ percent solids of 40%, 45%, 50%, and 80% (Appendix C). Trends between wet cake production, water requiring treatment and percent solids in-situ are summarized below.

Table 4-1
New Bedford Harbor Bench Scale Dewatering Mass Balance Trend

% solids in-situ	Yd^3 wet cake/hr			Water to treatment gpm		
	Koester	MPS	JCI/Upcycle	Koester	MPS	JCI/Upcycle
40	26	36	63	206	186	121
45	31	43	74	184	161	84
50	35	50	86	160	156	74
80	78	109	45	0	342	162

As indicated by the trends the Koester process water requiring treatment is decreasing with increasing in-situ percent solids and suggests a potentially higher efficiency due to minimized filter cake volume. Net costs associated with Koester's and MPS's processes, including utilities, makeup water, water treatment, and off-site disposal cost are summarized below.

Table 4-2
New Bedford Harbor Dewatering Cost Based on Mass Balance Calculations

		Koester			MPS		
In-situ % solids	(yd^3/hr)	40	50	80	40	50	80
Dredge Rate	(yd^3/hr)	75	75	75	75	75	75
In-situ Dewatering Cost[1]	($/$yd^3$)	50	50	50	15.39	15.39	15.39
Filter Cake Production	(yd^3/hr)	26	35	78	36	50	109
Filter Cake Production	(ton/hr)	35	48	105	47	64	141
Disposal Cost[2]	($/ton)	132	132	132	132	132	132
Filtrate to treatment[3]	(gal/mm)	206	160	0	186	156	342
Water treatment cost	($/gal)	0.03	0.03	0.03	0.03	0.03	0.03
Electricity Required[4]	(kWh/ton)	3.5	3.5	3.5	9.6	9.6	9.6
Electricity Cost	($/kWh)	0.1	0.1	0.1	0.1	0.1	0.1
Dewatering and Disposal Cost	($/in-situ yd^3)	117	139	235	103	133	274
Dewatering and Disposal Cost	($/in-situ ton dry solids)	257	226	176	228	216	205

Notes:
1. $50/in-situ cubic yard is based on conversation with Koester representative
2. Based on Table 6-1
3. Based on Appendix C, Dredging Mass Balances
4. Based on METHA plant data, Hamburg, Germany

4.4.2 Plate and Frame Filter Press vs. Belt Filter Press

The plate and frame filter press produces a filter cake with a higher percent solids (60% vs. 45%) and larger volume reduction (~40% vs. negligible) than the belt filter press. The only real advantage that the belt filter press would appear to have over the plate and frame filter press is cost. Based on the results of the bench scale tests the belt filter press is estimated to have a cost of $40 – 45/in-situ yd^3 versus $68/in-situ yd^3 for the plate and frame filter press system. However, JCI/Upcycle's cost does not include sand separation (which can be up to 20% of the total cost), or utility costs (water, electricity). Therefore, once these costs are accounted for, the costs of the two dewatering systems are essentially the same.

4.4.3 Plate and Frame Filter press vs. Bladder Press

As was indicated previously, the Bladder press is a combination of a belt filter press and a plate and frame filter press. Based on the bench scale test results, both of these desanding/dewatering systems are capable of producing a filter cake with a solids content of 50 to 60% solids (by weight). However, Koester was able to consistently achieve +60% solids and each successive test generated a higher percent % solids content. MPS demonstrated that they could achieve +50% solids but not on a consistent basis. Koester was also able to provide an average volume reduction of 41% (based on water content) versus an average of 20% for the MPS process. Both desanding systems would be able to separate sand from the in-situ sediments.

MPS indicates that it can produce a filter cake with 55% solids for approximately $15/in-situ yd^3. This is less than ¼ the costs estimated by Koester ($68/in-situ yd^3). Neither cost includes mobilization/ demobilization which is estimated to be approximately $1.5 million. As a result, the bladder press would appear to be the most cost effective desanding/dewatering system. However, the level of confidence for the bladder press is much lower than that of the plate and frame filter press.

When comparing MPS and Koester dewatering costs based on mass balances, disposal and utility costs, price differences are much less than 25%. Table 4-2 shows that the cost for MPS to dewater 75 in-situ cubic yards with an in-situ solids content of 40% by weight is 14% lower than Koesters, at 50% in-situ solids MPS cost is estimated to be 5% lower than Koesters cost, and at 80% Koester's cost is 13% below MPS's cost.

The plate and frame filter press has been successfully utilized on a number of sediment dewatering projects in the United States and Canada. On the other hand, very little project information is available in the United States for the bladder press. The bladder press is manufactured in Austria and to date only one desanding/dewatering application (METHA, Hamburg, Germany) has been found. In addition, MPS's experience comes nearly exclusively from the mining/power plant industry and as a result they admittedly do not have a good understanding of the requirements (health and safety, QA/QC, etc.) of a Superfund project. As a result, it is believed that MPS's cost will likely increase. The degree to which it does is not known but it is unlikely to exceed the costs of a plate and frame filter press system.

Given the project's need to reduce the volume/weight of the in-situ sediments to be disposed of in an on-site or off-site landfill, it is recommended that either the plate and frame filter press or the bladder press be utilized to dewater the dredged sediments.

Table 4-3

New Bedford Harbor Sediment Dewatering Investigation
Vendor Process/Technology Comparison Table

Based on 45% in-situ solids by weight
75 in-situ yd3/hr
Through a Slurry Processing Unit with an output consisting of 15% solids by weight

Vendor	Sand Separation Process [3]	Dewatering Process [3]	Water Content[4] (%)	Filter Cake % Solids (w/w)	Volume [1] Reduction (%)	Cost [2] ($/in-situ cy)	Assumptions
JCI/ UPCYCLE	Vendor indicated that no significant sand fraction was present in sediment provided by FWENC. Bench scale sample was only passed through a 35 mesh screen. No full scale sand separation process was proposed.	**Belt Filter Press** - Continuously dewater 6-12% solids (w/w) dredge slurry. - 63-120 lbs/hr polymer added to form flocculant - 43-98 yd^3/hr filter cake @45% solids (w/w) and 1,500 gpm slurry flow rate	Based on Bench Scale Results 122% ——— Based on Mass Balance 122%	45.0%	Based on Water Content Negligible ——— Based on Mass Balances Negligible	$40 - $45 $30 -$33.75 million	1) 500,000 cy of sediment to be processed (150,000 cy per year for ~3.25 years) 2) No coarse separation required. Additional costs if needed. 3) Non-potable water will be supplied to JCI/UPCYCLE at no cost (minimum flow rate required: 180gpm @80psig) 4) Electrical service and power will be supplied to JCI/UPCYCLE at no cost 5) Dewatering operations will generate water requiring treatment. 6) Dewatering solids will be removed by others in a timely manner to decrease process inefficiencies. 7) Decontamination of all dewatering equipment will not be JCI/UPCYCLE's responsibility.
KOESTER	1) 250,000 gallon equalization tank/basin 2) 3/8" vibrating screen 3) V-bottom tank with recirculating pump 4) Hydroclones 5) 200 mesh vibrating screen 6) Holding tank feed pumps	**Diaphragm Plate and Frame Filter Press** - Batch (semi-continuous) process - Desanded 15% solids slurry is mixed with a polymer and then processed through a diaphragm plate and frame filter press	Range Based on Bench Scale Results 50-60% ——— Based on Mass Balance 67%	60.0%	Based on Water Content 45% ——— Based on Mass Balances 59%	$68.5 $51.38 million	1) 750,000 cy of sediment to be processed (250,000 cy per year for 3 years) 2) Production will take place over two 10 hours shifts per day, 6 days per week for the duration of the project. 3) Bench-scale samples and results are representative. 4) Dewatering operations will generate water requiring treatment. 5) Electrical service and power will be supplied at no cost 6) Non-potable water will be supplied at no cost 7) Mobilization = $1.6 million 8) Dewatering solids will be removed by others in a timely manner
MPS	Concurrent sand washing process which includes: 1) Spiral Dewaterer with flash mix chamber and elevating screw 2) Vibrating Screen deck with wash troughs (100 mesh) 3) Sediment thickener/clarifier (includes polymer addition)	**Bladder Press** - Continuous process dewaters 34% solids slurry - Desanded, conditioned slurry is fed at a low pressure to bladder press where the bladder cavity is filled with water to apply increasing pressure to the slurry.	Range Based on Bench Scale Results 61-112% ——— Based on Mass Balance 82%	55.0%	Based on Water Content 33% ——— Based on Mass Balances 42%	$15.39 $11.5 million	1) 750,000 cy of sediment to be processed (250,000 cy per year for 3 years) 2) Production will take place over two 10 hours shifts per day, 6 days per week for the duration of the project. 3) Bench-scale samples and results are representative. 4) 23% of in-situ dry solids will be >100 mesh and uncontaminated. 5) System capacity is 650gpm. 6) Dewatering operations will generate water requiring treatment. 7) Electrical service and power will be supplied at no cost 8) Non-potable water will be supplied at no cost 9) Dewatering solids will be removed by others in a timely manner to decrease process inefficiencies. 10) Does not include costs for mobilization

Notes:
(1) Based on water content / Mass Balance Calculations
(2) Based on bench scale test price quotes
(3) As shown in Feasibility Investigation of Sediment Dewatering Alternatives, Appendix C , Dredging Mass Balances
(4) Based on mass balance calculations (weight of water)/(dry weight)
(5) % Solids - WT solids/total weight

4.5 Pilot Scale Dewatering Test(s)

Given the large volume of material to be removed and dewatered, all three bench scale vendors recommended that pilot scale dewatering tests be conducted utilizing the sediments dredged during the pre-design field test. A pilot test would enable the vendors to develop operational data to refine their dewatering cost estimates. Factors that influence a final budget estimate for dewatering with a belt filter press or plate and frame filter press are presented in the following text and summarized in Table 4-4.

Table 4-4
Summary of Factors Affecting Final Dewatering Costs

Plate and Frame Filter Press	Belt Filter Press
• Efficiency of desanding system • Levels of contamination in coarse separated material (material >100 mesh) • Polymer usage • Equipment/pump wear • Dewatering cycle times • Filter cake properties (thickness, density) • Variations in influent percent solids	• Ensure that PCB contamination will not inhibit floccule formation on a commercial scale • Polymer usage • Material throughput • Product quality

Factors that will affect a final budget estimate for the plate and frame filter press that can be addressed in pilot scale testing include:

- Efficiency of desanding system. The efficiency of the desanding unit will affect the percent solids of the influent, polymer usage, pump feed rates, unconfined compressive strength of the filter cake, cake density, filter cloth wear, and cake release.
- Contaminant levels within screened material (+3/8 and +200 mesh) after a pilot desanding project would reveal whether the coarse separated material would be above or below the TSCA threshold. This could allow other options for the disposition of the separated material.
- Polymer cost could be as high as 10% of the dewatering costs. The cost provided in the estimate was based upon a small sample of the in-situ material. A full-scale pilot project would result in a more accurate application rate and may reduce current projected polymer usage by as much as 50% (~\$3.5/insitu yd^3 or \$2.625 million).
- Equipment/pump wear in the forecast budget included repair of parts. A pilot project would enable the subcontractor to more accurately predict the equipment wear depending on the efficiency of the desanding operation. Excessive wear would require inclusion of replacement costs in final budget.
- A pilot project would provide more accurate cake thickness, density results and allow for revised cycle times and production rates.
- Variations of influent percent solids. On the full size presses the subcontractor could maximize the % solids to the conditioning tanks and presses. The pilot project would give an accurate estimate on the cake tons produced, cycle times, and polymer use for a maximum % solids treatment plan.

Factors that will affect final budget estimates for the belt filter press that could be addressed in a pilot scale test include:

- Scale-up of the belt filter press dewatering process to determine the proper sediment and refining of operational parameters such as confirmation of raw sediment quality, material handling, configuration, site requirements, client objectives and product quality requirements to the New Bedford Harbor project.
- Assurance that PCB contamination will not inhibit floccule formation on a commercial scale, additional testing and data generation from a pilot test effort is warranted.
- Confirmation of these projections for throughput, chemical dosage and product quality, the key criteria impacting belt filter press dewatering costs. A pilot effort would allow for the refinement of estimated processing costs.

Given the high level of confidence associated with the plate and frame filter press system, it is not believed that a pilot scale test would significantly change the estimated treatment cost of \$50/in-situ yd^3. A small scale dewatering test would, however, be very beneficial in the evaluation of the belt filter press and bladder press systems. A pilot scale test would demonstrate whether the belt filter press and bladder press could consistently and effectively desand and dewater the New Bedford Harbor sediments.

Another benefit of a pilot scale test would be that a large volume of filter cake would be generated that could be utilized to conduct a variety of material handling and geotechnical analyses. This data would be valuable for the design of the CDFs.

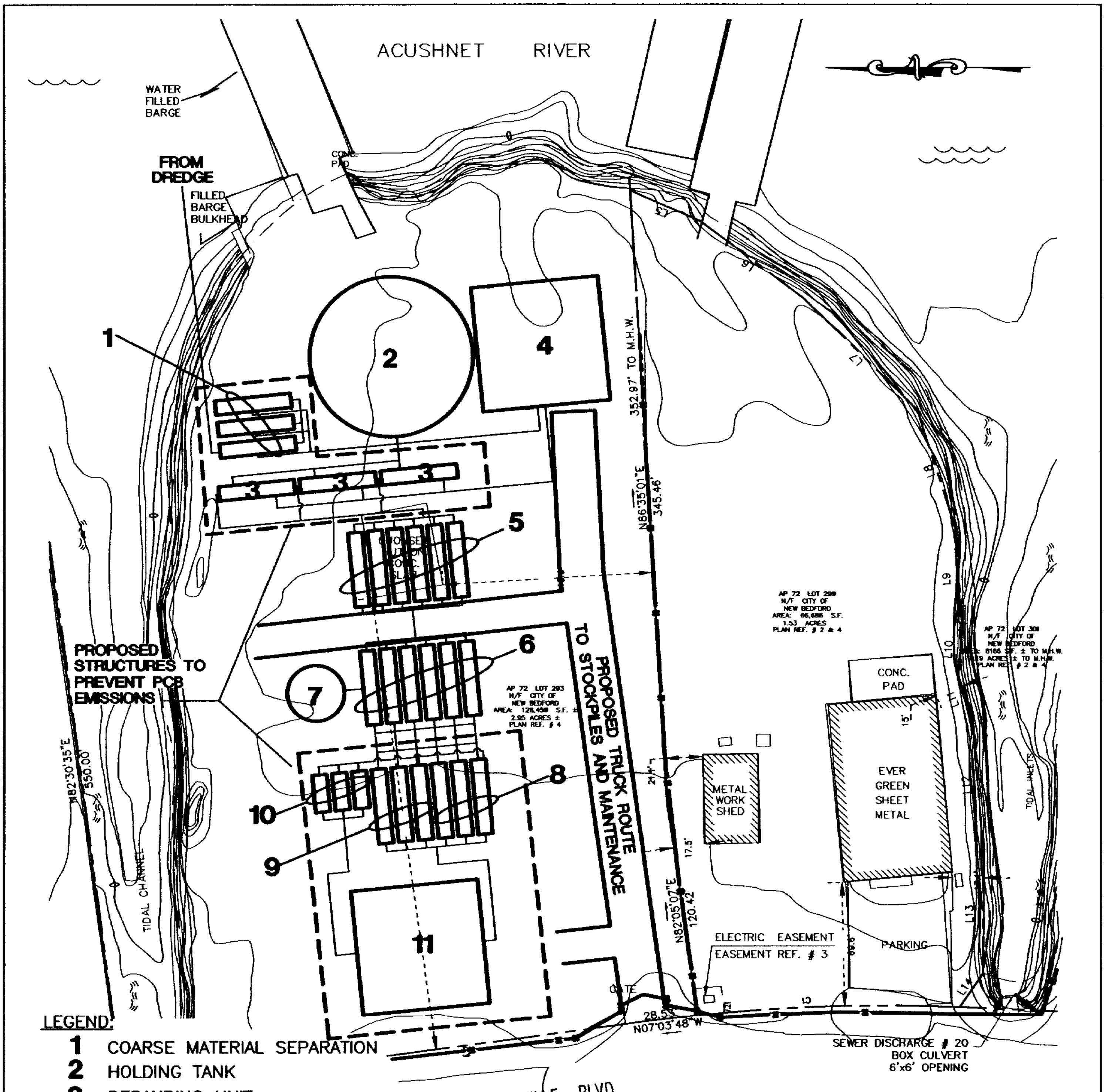
5.0 DESANDING/DEWATERING SITE LAYOUTS

Assuming a mechanical excavation, hydraulic transport (MEHT) dredge ("Bean" type dredge) is utilized, a desanding and dewatering system sized for a 75 in-situ yd^3/hr dredge rate will require a surface area of approximately 0.5 acres and the additional storage areas and slurry holding tank(s), will require an additional 1.3-1.5 acres.

Koester's system (complete with material storage) will require 1.8 to 2.0 acres, of which approximately 210 feet by 100 feet are for the desanding/dewatering equipment. The MPS system will require an area of approximately 95 feet by 182 feet for their desanding/dewatering equipment to process 75 in-situ cubic yards of sediments per hour.

Figure 5-1 depicts a desanding and dewatering system layout based on a Koester type system located near CDF D. Redundancy is built into the system in order to prevent dewatering shutdown if one unit is taken offline for repairs, cleaning, or routine maintenance. It does not appear that CDF C has sufficient area for a 75 in-situ yd^3/hr dewatering system. Therefore, a system layout is not provided for CDF C and the overall evaluation of the dewatering costs must include transportation of dewatered filter cake to CDF C during the construction of CDF D. The location of the dewatering system is done in order to show relative size. The dewatering system consists of:

1) Coarse material (+3/8") separation and storage.
2) Holding tank (completely enclosed), Slurry Pressure Unit (SPU), approximately 500,000 gallons with jet pumps for suspension of sediments.
3) Desanding unit, consisting of hydrocyclones and +100 reject screen, approximate footprint 42' by 8'.
4) Sand storage area capable of holding ten twenty-hour days of sand generation, approximately 70' by 70' by 6' high (~1000 cubic yards).
5) Equalization Tank (completely enclosed), approximate footprint 42' by 8' for each unit, total of 6 units.
6) Polymer Conditioning Tank (completely enclosed) with a 300 gallon polymer holding tank, approximate footprint 42' by 8' for each unit, total of 6 units.
7) Polymer holding tank (completely enclosed), 10,000 gallon.
8) 400 cubic feet filter press, approximate footprint 42' by 8' for each unit, total of 3 units.
9) 240 cubic feet filter press, approximate footprint 42' by 8' for each unit, total of 3 units.
10) Compressor.
11) Enclosed filter cake storage area, capable of holding two twenty-hour days generation of filter cakes, approximately 70' by 70' by 6' high (~1000 cubic yards).



LEGEND:

1 COARSE MATERIAL SEPARATION
2 HOLDING TANK
3 DESANDING UNIT
4 SAND STORAGE AREA
5 EQUALIZATION TANK
6 POLYMER CONDITIONING TANK
7 POLYMER HOLDING TANK
8 400 CUBIC FEET FILTER PRESS
9 240 CUBIC FEET FILTER PRESS
10 COMPRESSOR
11 FILTER CAKE STORAGE AREA

NOTES:

1. FOR DIMENSIONS AND DETAILS, REFER TO SECTION 5.0 OF REPORT.
2. COMPONENTS REQUIRED TO SUPPORT DESANDING OPERATIONS WITHOUT DEWATERING ARE 1, 2, AND 3.

FIGURE 5-1

NEW BEDFORD HARBOR SUPERFUND SITE
NEW BEDFORD HARBOR, MASSACHUSETTS

CONCEPTUAL DESANDING/ DEWATERING LAYOUT AT CDF D

SCALE: AS SHOWN

CAD FILE: CDFD-3a.DWG

6.0 REUSE AND DISPOSAL OPTIONS

The reuse and disposal options for the dredged sediments will vary depending on the level of contamination. The following sections discuss the transportation and disposal options for TSCA material, and the potential reuse of the separated sand fraction.

6.1 Transportation and Disposal - TSCA

Transportation and disposal costs were obtained from four different disposal facilities for the filter cake to be generated by the mechanical dewatering process. The facilities contacted were Chemical Waste Management – Model City, NY; Chemical Waste Management – Emelle, AL; EQ – Belleville, MI; and Safety-Kleen – Grassy Mountain, Utah. Three different transportation options were also evaluated and included: trucking, trucking/rail, and rail. A summary of the costs for each facility, and transportation option is provided in Table 6-1. Dewatering costs are also provided in Table 6-1.

The following assumptions were utilized for the transportation and disposal options:

- Total volume of in-situ sediment to be dredged = 750,000 yd^3.
- Sand and course reject will be considered Non-TSCA.
- Mechanical desanding/dewatering with plate and frame filter press will reduce the in-situ sediment volume by 59% based on mass balance for 45% in-situ solids by weight.
- Mechanical desanding/dewatering with a bladder belt filter press will reduce the in-situ sediment volume by 42% based on mass balance for 45% in-situ solids by weight.
- Mechanical desanding/dewatering with belt filter press will have a negligible reduction of the in-situ sediment volume.
- Filter cake densities are calculated based on mass balances 45% in-situ solids.
- Filter cake densities are based on mass balance calculations provided in Appendix C.
- Dredging, desanding and dewatering activities will begin October 2001.
- Project will either have a 3 or 5 year life.
- Trucking/rail option assumes material is trucked to Worcester, Massachusetts and then transferred to railcars.
- Rail option assumes that rail lines to New Bedford, Massachusetts are operational. Cost of rail spur to CDF D or upgrades/repairs to the existing CSX rail lines is not included.
- Cost for disposal of oversized material and sand fraction is not included. The cost is the same for the alternatives and would not influence the comparison.

All four facilities indicated that they would have sufficient capacity to accept the annual tonnage for both the 3 and 5 year scenarios. Each facility also indicated that the prices quoted are conservatively high given the uncertainty for off-site disposal occurring. However, each facility is very interested in having the filter cake disposed of at their facility and as a result a competitive bidding process may reduce the transportation and disposal costs.

6.2 Potential Reuse of Sand Fraction

Depending on the concentration of contaminants in the separated sand and applicable regulations, the material could be disposed of off-site in a non-TSCA landfill or utilized on site within the CDFs (i.e., vent sand layer).

The bench scale dewatering data indicates that the separated sand (+200 mesh) has a PCB concentration of 49 ppm, which is borderline non-TSCA ($\geq$ 50 ppm PCBs). The presence of a light coarse fraction may be responsible for the high residual PCB concentration in the sand. A separation process with a gravity component (upflow, hydrocyclones) may help lower this concentration further. However, the mechanical separation of the sand component of the excavated material from the remaining material may be subject to TSCAs "Mega Rule" which states that separated materials from a TSCA waste are still considered to be TSCA even though their concentration may be below 50 ppm. This provision was developed in order to prevent waste containing PCBs $\geq$ 50 ppm from being diluted in order to comply with TSCA provisions. The separation of the sand may be construed by USEPA to be a form of impermissible dilution (i.e., separating out a TSCA regulated materials into components which individually would not be subject to TSCA).

However, the "Mega Rule" also has a provision for PCB remediation wastes. Under this provision, the material could be disposed of in a non-TSCA, RCRA facility even if the material contained greater than 50 ppm PCBs. Therefore, the sediment could be considered remediation waste and the sand could then be disposed of off-site in a RCRA permitted facility.

To further complicate the issue, even if the agencies determine that the material is exempt from the "Mega Rule" a non-TSCA disposal facility could still decide not to accept the material for liability or permit reasons. Therefore, confirmation of the applicability of the TSCA anti-dilution rule should be confirmed through discussions with the EPA Region I TSCA Coordinator and non-TCSA disposal facilities.

Any upland reuse land application of the separated sand fraction must first meet Section 401 Water Quality Certification Standards to address potential runoff into surrounding surface water bodies. Contaminant levels must also be less than the MCP Soil 1 and Ground Water 1 Standards (< 2 ppm PCBs). The non-degradation provision of the MCP applies, i.e., contaminant concentrations in applied sediments cannot exceed concentration of contaminants in receiving land.

The separated sand may also be reused or disposed of in an existing solid waste landfill. The MADEP makes the distinction between reuse and disposal of sediments. Reuse constitutes the beneficial use of sediments as a daily cover, intermediate cover and pre-cap contouring material. Disposal constitutes burial in a landfill. Dredged sediments are not to be reused or disposed of at an unlined landfill. Sediments are not to be disposed of at lined landfills if a feasible alternative exits for its reuse, recycling, destruction, and/or detoxification. The maximum allowable contaminant level of PCBs for dredged sediment reuse or disposal at lined landfills is <2 ppm.

A more detailed discussion of the applicable regulatory programs with respect to the separated sand fraction is provided in Appendix D.

Table 6-1: Summary of Mechanical Dewatering, Transportation and Disposal Costs
New Bedford Harbor Superfund Site - OU#1

Mechanical Dewatering Option	Mechanical Dewatering Cost	Off-Site Disposal Facility	Off-Site Disposal Cost ($/ton)	Off-Site Transportation Option	Off-Site Transportation Cost ($/ton)	Total Cost Transportation	Total Cost
Belt Filter Press 750,000 yd^3 in-situ 0% Volume Reduction[5] 750,000 yd^3 filter cake 888,000 tons filer cake 45% solids 1.18 tons/yd^3	$40 - $45 in-situ yd^3 **$30-33.75 million** project cost	CWM - Model City, NY[1]	$107.06	Trucking	$80.00	$165,548,100	$195,548,100
		CWM - Emelle, AL[2]	$157.28 $132.28	Trucking/Rail Direct Rail[6]	Included in Disposal Cost Included in Disposal Cost	$139,192,800 $117,067,800	$169,192,800 $147,067,800
		EQ - Belleville, MI[3]	$50.00 $50.00 $50.00	Trucking Truck/Rail Direct Rail[6]	$110.00 $82.00 Not Available	$141,600,000 $116,820,000 -	$171,600,000 $146,820,000 -
		Safety Kleen - Utah[4]	$154.00 $140.00	Trucking/Rail Direct Rail[6]	Included in Disposal Cost Included in Disposal Cost	$136,290,000 $123,900,000	$166,290,000 $153,900,000
Plate & Frame Filter Press 750,000 yd^3 in-situ 59% Volume Reduction[5] 307,500 yd^3 filter cake 418,200 tons filter cake 60% solids 1.36 tons/yd^3	$68.50 in-situ yd^3 ***$51,375,000*** project cost	CWM - Model City, NY[1]	$107.06	Trucking	$79.92	$78,195,036	$129,570,036
		CWM - Emelle, AL[2]	$157.28 $132.28	Trucking/Rail Direct Rail[6]	Included in Disposal Cost Included in Disposal Cost	$65,774,496 $55,319,496	$117,149,496 $106,694,496
		EQ - Belleville, MI[3]	$50.00 $50.00 $50.00	Trucking Truck/Rail Direct Rail[6]	$110.00 $82.00 Not Available	$66,912,000 $55,202,400 -	$118,287,000 $106,577,400 -
		Safety Kleen - Utah[4]	$154.00 $140.00	Trucking/Rail Direct Rail[6]	Included in Disposal Cost Included in Disposal Cost	$64,402,800 $58,548,000	$115,777,800 $109,923,000
Bladder Press 750,000 yd^3 in-situ 42% Volume Reduction[5] 435,000 yd^3 filter cake 561,150 tons filter cake 55% solids 1.29 tons/yd^3	$15.39 in-situ yd^3 ***$11,542,500*** project cost	CWM - Model City, NY[1]	$107.06	Trucking	$79.92	$104,923,827	$116,466,327
		CWM - Emelle, AL[2]	$157.28 $132.28	Trucking/Rail Direct Rail[6]	Included in Disposal Cost Included in Disposal Cost	$88,257,672 $74,228,922	$99,800,172 $85,771,422
		EQ - Belleville, MI[3]	$50.00 $50.00 $50.00	Trucking Truck/Rail Direct Rail[6]	$110.00 $82.00 Not Available	$89,784,000 $74,071,800 -	$101,326,500 $85,614,300 -
		Safety Kleen - Utah[4]	$154.00 $140.00	Trucking/Rail Direct Rail[6]	Included in Disposal Cost Included in Disposal Cost	$86,417,100 $78,561,000	$97,959,600 $90,103,500

Notes: Oversized material and the sand fraction will not affect the cost comparison (same amount for all alternatives)

1. Assume 187,500 tons/year
   Disposal cost include 6% local tax
   4% annual increase in disposal and local taxes
   Three year disposal/tax cost = $107
   Five year disposal/tax cost = $111.30
   Transportation cost include 11% fuel surcharge
2. Assumes volume will meet or exceed 95% of 500,000 ton volume
   Disposal cost includes local tax
   Charges not included: $250/railcar requiring decon, 6% possible fuel surshargе, and $75/day/car demurrage after 48 hours.
   Three year average cost = $132.28/ton
   No costs provided for 5 year scenario
3. Assume 187,500 tons/year
   Disposal cost does not include local tax
   Disposal cost is for 3 and 5 year scenarios
   Transportation cost includes $10/ton fuel surcharge
4. Assume 187,500 tons/year
   Disposal is including transportation cost
   Disposal cost is for 3 year scenario
   Disposal cost does not include MA tax
   Disposal cost does not include loading of gondolas
5. Estimated volume reduction based on Benchscale dewatering results.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the information gathered for this feasibility investigation the following conclusions and recommendations have been developed:

Physical Separation

Physical separation of the +100/+200 mesh material from the dredged sediment is technically feasible and would result in an in-situ volume reduction of approximately 5-10%. The most likely separation process would include pre-processing with a grizzly at the dredge followed by sand separation with hydrocyclones, vibrating screens and/or screw classifiers.

During the Pre-Design Field Test, coarse debris (>8") was removed by a grizzly consisting of perpendicular bars with a distance of 6" by 6" located on the top of a hopper. A mini excavator was installed next to the grizzly to pick-up debris and to dispose it into a trash bin installed next to the hopper. The debris consisted of rocks, chains, cables, steel construction pieces, tires, wood, and plastic sheets.

Small debris (>4") was removed with a rockbox with a screen with 4" openings. The rockbox was installed in the suction line between the hopper and the slurry pump. On the average the rockbox had to be emptied twice a day, when it was filled with rocks, shells, pieces of steel, plastic, and horse-shoe crabs.

Analytical data from Koester's bench scale testing indicates that the + 200 mesh material separated in the desanding process is borderline non-TSCA (49 ppm). More aggressive washing may further reduce the PCB concentration. A larger mesh screen (i.e., 100 mesh) may also allow more of the organic clays to pass thus lowering the PCB concentrations. However, final screen sizes will be determined by the geotechnical requirements of the filter cake and the materials final disposition (off-site/on-site disposal).

Mechanical Dewatering

All three of the dewatering technologies evaluated are considered technically feasible. However, for the New Bedford Harbor project only the plate and frame filter press and the bladder press were shown to be capable of achieving the projects volume reduction or weight reduction objectives. Both technologies demonstrated during bench scale testing that they are capable of producing a filter cake with a solids content of 50 to 60% solids (by weight

Of the two dewatering technologies being considered, the bladder press appears to be the least costly proposal. MPS indicates that it is capable of producing a filter cake with a high percent solids slightly below the plate and frame filter press (55-60% vs. >60%) at a cost of approximately \$15/in-situ yd^3. Compared to the estimated plate and frame filter press cost of \$68/in-situ yd^3 the cost savings are significant (\$11.54 million vs. \$51.38 million). However, the level of confidence is much lower with a bladder press system. Unlike Koester, during the bench scale tests MPS could not consistently produce a 50% to 60% solids filter cake.

When comparing MPS and Koester dewatering costs based on mass balances, filtrate treatment, disposal and utility costs, price differences are much less significant than when comparing \$15/in-situ yd^3 with \$68/in-situ yd^3. Prices based on mass balance calculations are 31% and 19% lower for MPS at 40% and 50% respectively. At 80% in-situ solids by weight Koester's price is 7% lower than MPS's.

The plate and frame filter press is a proven technology while no North American projects that utilized the bladder press are known. The only known project utilizing the bladder press with success is located in Hamburg, Germany (Appendix B, Bench Scale Dewatering Test Reports, Mineral Processing Services).

While the current difference in price between the two technologies is significant, Koester has explained that they gave a conservative estimate due to uncertainties and that the competitive price would likely be in the $50.00 per in-situ cubic yard. This number has been verified in conversation ($50 ± 10%) with Mobile Dredging & Pumping Co., (a plate and frame filter press vendor), during a site visit (Appendix A). Based on the bench scale results, the lack of information about the bladder press, and MPS's apparent lack of Superfund experience, the level of confidence in bladder press costs is low relative to Koesters. However, while the likelihood of the two costs being equal are minimal, the differential will surely decrease.

Changes that may lead to closer estimates are:

- *Environmental experience* - Koester has experience with environmental work, specifically with Superfund sites while MPS has no environmental experience. MPS has expressed interest in meeting and discussing environmental health and safety issues with Foster Wheeler and the expected outcome of the meeting is an increase in price.

- *Differences in Primary Size Reduction* - Koester is screening with a 200-mesh screen while MPS is using a 100-mesh. Either Koesters price will be reduced if it is decided that 200-mesh screening is not required or MPS's price will increase if the 200-mesh screen is required. The final mesh utilized will be determined once all geotechnical data is received.

- *Pilot study* – Both Koester and MPS have indicated a pilot study may decrease the price due to more accurate knowledge of polymer usage, equipment wear, revised cycle times and production rates. However, since the confidence level is high for the plate and frame filter press system, a pilot test would be more beneficial to MPS.

Therefore, given the project's need to reduce the volume of dredged sediment placed in CDFs or weight if disposed of off-site, it is recommended that either the plate and frame filter press or the bladder press be utilized to dewater the sediment. The plate and frame filter press system has been demonstrated to be effective in dewatering sediments on a number of remedial projects. However, even though the bladder press is currently only known to have been used at one site (Hamburg, Germany) it's unit treatment cost makes it an attractive dewatering option. In order to make a more comparable evaluation of the two dewatering technologies it is recommended that the following actions be taken:

1. Continue to discuss the applicability of the two technologies with dewatering vendors, including Koester and MPS;
2. Visit the Hamburg, Germany project to see first hand how the bladder press is being applied and how effective the system is; and
3. Conduct full scale dewatering during the construction of CDF C (approximately 9,000 cubic yards of contaminated sediments).

Pilot Scale Dewatering Tests

All three of the bench scale vendors have made cases for conducting a full- scale pilot test. The primary benefit of conducting a pilot scale dewatering test is to obtain geotechnical data (strength, creep, volume reduction) of the filter cake to support the design of CDF D. These geotechnical parameters are not as critical to the design of CDF C.

The secondary reason for conducting a pilot test is to refine operating costs. However, given the high level of confidence associated with the plate and frame filter press system, it is not believed that a pilot scale test would significantly change the estimated treatment cost of $50/in-situ yd^3. A small scale dewatering test would, however, be very beneficial in the evaluation of the bladder press system. A pilot scale test would demonstrate whether the bladder press could consistently and effectively desand and dewater the New Bedford Harbor sediments.

Transportation and Off-Site Disposal

All four of the TSCA disposal facilities contacted indicated that they would have sufficient capacity to accept approximately 187,500 tons of filter cake per year. This volume would correspond to a project duration of 3 years. Transportation and disposal costs for the dewatered sediment ranged from $132 (EQ-Belleville, Michigan; Truck/Rail) to $187 (CWM-Model City, NY; truck). The most cost effective transportation and disposal option would be trucking to a transfer station in Worcester, Massachusetts and then rail to EQ's Belleville, Michigan facility. The transportation and disposal cost for this facility is $132/ton. This translates into a total transportation and disposal of $74,071,800 for filter cake from a bladder press, $55,202,400 for filter cake from a plate and frame filter press, and $116,820,000 for filter cake from a belt filter press.

The bench scale tests data indicates that with a more aggressive washing system, the separated sand could potentially be non-TSCA (<50 ppm PCBs) and thus can be disposed of as a non-TSCA waste. The sand may also potentially be used on site within the CDFs (i.e., sand vent layer). However, it does not appear likely that the separated sand will be sufficiently clean (< 2 ppm) to be used within the wetlands. There is also some uncertainty as to whether separating the sand constitutes dilution. The "Mega Rule" allows for the disposal of PCB contaminated remedial wastes in a non-TSCA facility, however, a final decision will need to be made by the regulatory agencies (USEPA, MADEP).

Given the level of uncertainty associated with the final volume of sediment that will be removed from the upper and lower estuary of New Bedford Harbor off-site disposal is an option to meet disposal needs should sufficient CDF capacity not be available or should the cost per unit volume for disposal in CDFs be greater.

8.0 REFERENCES

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